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RUDIMENTARY TREATISE

ON

THE POWER OF WATER.

RUDIMENTARY TREATISE

ON THE

POWER OF WATER.

AS APPLIED TO DRIVE FLOUR MILLS, AND TO GIVE MOTION TO TURBINES AND OTHER HYDROSTATIC ENGINES.

BY

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WITH ILLUSTRATIONS,

AND

AN APPENDIX ON CENTRIFUGAL AND ROTARY PUMPS.

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RUDIMENTARY TREATISE

ON

THE POWER OF WATER.

PREFACE.

Some of the most pleasant days of the author's early life were passed on a small, but picturesque estate belonging to his family, on which were three corn mills—one driven by wind, and two by water. To his youthful associations with these and their tenants may in part be owing his attachment to mechanical pursuits. Subsequently his father was induced, as an investment, to build, on other property, a flour-mill driven by steam, to which, during its erection, he was a daily visitor.

In after life his professional employment as a civil engineer frequently involved the construction of water-wheels, many of them on a large scale, for drainage and irrigation, and for motive power, besides hydraulic works of various kinds.

Few persons have had occasion to use the steam-engine more extensively, and he is fully sensible of its great value and importance as a prime mover for machinery; yet he has often felt that water-power has been unduly superseded or neglected when it might have been usefully employed; there are many places where fuel is scarce, where water abounds, and where mechanical power is wanted, but much expense cannot be afforded; and if motive power be used at all, it must be obtained at light cost.

In such circumstances are some of the colonies, and many parts of Ireland: there water-power must precede the steam-engine and be the pioneer to manufacturing industry.

He has often contemplated writing some short and popular work on this subject, whenever an opportunity might present itself: this has now occurred in the publication of a series of rudimentary books by Mr. Weale; and having already written one of these, a "Rudimentary Treatise on Cranes," which has circulated very extensively, and been translated into several foreign languages, he has been induced to devote such intervals of leisure as he could obtain to the production of the present volume.

It is with much satisfaction he inscribes this Rudimentary Treatise on Water Power to the Earl of Rosse; not only from his lordship's well-known attachment to science, but from his practical knowledge and skill in the mechanical arts, and his zeal for the benefit and improvement of his country. It will be most gratifying to the author if this little book contribute in any way to extend the employment of a power which Ireland so largely possesses, or to aid in advancing the progress of manufacturing industry in the sister island.

J. G.

London, December, 1852.

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RUDIMENTARY TREATISE

ON

THE POWER OF WATER

TO TURN MILLS AND GIVE MOTION TO MACHINES.

CHAPTER I.

THE EARLY USE OF MILLSTONES TO GRIND CORN, AND THE EMPLOYMENT OF WATER AS A MOVING POWER.

ALTHOUGH labour is the lot of man, and is indeed necessary to his existence, yet the human mind naturally revolts from those kinds of labour in which it takes no part, and in all ages men have endeavoured to shun mere toil involving only the employment of animal strength without the exercise of thought or dexterity. Thus it has ever been from the earliest ages even until now, that occupations requiring nothing beyond the exertion of muscular force have been assigned to persons taken captive in war, or sold into slavery, or reduced by other misfortunes to perform constant and monotonous labour.

Such were of old the hewers of wood and the drawers of water, and when corn was first ground to make bread, the task of turning the mill was performed by the bondman or the captive, or else among rude tribes it was imposed on the women of the family while the men were engaged in war or in the chase.

Thus we read in the book of Judges, when the Philistines heaped injury and insult on their fallen foe, "they put out

his eyes and bound him with fetters of brass, and he did grind in the prison-house."

So when the Prophet foretells the utter destruction and desolation of a great and mighty empire he says, "Come down and sit in the dust, O virgin daughter of Babylon, sit on the ground: there is no throne, O daughter of the Chaldeans: for thou shalt no more be called tender and delicate. Take the millstones and grind meal."

The grinding of meal appears to have been performed in very remote ages by a pair of millstones, similar in form and in principle to those at present in use, the difference being chiefly in their size and in the mode of driving them. The Mosaic law says, "No man shall take the nether or the upper millstone to pledge: for he taketh a man's life to pledge." Such millstones were used by the Roman legions in Britain, and are often found about their ancient camps and stations, but nowhere perhaps in such number and variety as in the county of Northumberland, along the line of the Roman wall, and many fine examples are preserved by the Antiquarian Society of Newcastle-upon-Tyne.

These are generally about a foot in diameter, and made of the hard sandstone found in the coal districts, hence called millstone grit. The lower millstone was stationary; sometimes it was made larger than the upper stone, and had a rim or border to confine the meal and cause it to be delivered by a spout into a shallow vessel or sieve, but generally it was a round stone of the same size as the top stone, and must have been set on a cloth spread upon the ground to receive the meal.

An upright pin or pivot fixed in the centre of the nether millstone formed a kind of axis, and passed through a hole in the upper stone, which like the nether millstone was of a flat circular form. The upper stone was fitted with a handle to drive it round, and make it revolve over the lower stone; sometimes the upper surface of the top stone was hollowed into a shallow dish to hold a portion of the corn to be ground, which was gradually shaken down the hole round the fixed axis by the motion of the mill.

It is curious to observe that the principles on which corn-mills were constructed thousands of years ago, remain the same to the present day, and "the work" as millwrights call it, that is the system of grooves cut in the grinding faces of the millstones which crossing each other when in motion act like a pair of shears to cut the grain and also to throw it out from the centre to the circumference, are now

CHAPTER III.

ON THE MEASUREMENT OF EFFLUENT WATER.

There is perhaps no point which has occasioned more dispute and litigation, than the conflicting rights of persons entitled to take water power, in certain proportions, from a common source, where the demand exceeds the supply; and there are perhaps few of greater interest at the present time, when the increased size and population of our towns and cities render their call for water imperative.

The conclusions arrived at by Mr. George Rennie, as reported in the Philosophical Transactions of the Royal Society, are,—

1. That the quantities discharged in equal times are as the areas of the orifices.

2. That the quantities discharged in equal times, under different heights, are *nearly* as the square roots of the corresponding heights.

3. That the quantities discharged in equal times, under different heights, are to each other in the compound ratio of the areas of the apertures, and of the square roots of the heights, *nearly*. The heights were measured from the centre of the apertures; and the mean of several experiments showed, that the co-efficients or numbers expressing the proportion between the theoretic discharge of the water, calculated as a falling body, and the actual discharge, as measured, are as under; all the openings being formed in brass plates $\frac{1}{20}$ of an inch thick.

Round hole, 1 inch diameter, with		4 ft.	head.	0·621
Do.	do.	1 ft.	„	0·645
Triangular hole (equilateral) 1 in. area		4 ft.	„	0·593
Do. do.	do.	1 ft.	„	0·596
Rectangular holes 1 in. sq. and 2 × ½		4 ft.	„	0·593
Do. do. do.	do.	1 ft.	„	0·616

The mean of all these numbers is ·610, and for the rectangular holes, it is ·600. Hence Mr. Rennie deduces the following formula:—

an, are for m ·419, and for k ·079; which last numb
g *multiplied* by 60, to make it the factor for feet

minute, gives 4·74. So that the first is slightly over Mr. George Rennie's ·400, and the second somewhat under the number 5·1 or 5·15 generally used. This is accounted for by so many experiments with low heads, as will be seen on referring to the next table, arranged by Mr. Blackwell.

TABLE *showing the* VARIATION *of the* CO-EFFICIENTS *for the different* HEADS OF WATER. (*m* and *k* mean Co-efficents.)

No. of trials.	Description of Overfalls.	Head in inches.	*m*	*k*
6	Thin plate 3 feet long . . .	1 to 3	·440	·085
	„ „ „ . . .	3 to 6	·402	·078
11	Thin plate 10 feet long . .	1 to 3	·501	·096
	„ „ „ . . .	3 to 6	·435	·086
	„ „ „ . . .	6 to 9	·370	·072
23	Plank 2 inches thick, with notch	1 to 3	·342	·066
	3 feet long	3 to 6	·384	·074
	„ „ „ . . .	6 to 10	·406	·077
56	Plank 2 inches thick, with notch	1 to 3	·359	·069
	6 feet long	3 to 6	·396	·077
	„ „ „ . . .	6 to 9	·392	·074
	„ „ „ . . .	9 to 14	·358	·069
40	Plank 2 inches thick, with notch	1 to 3	·346	·068
	10 feet long	3 to 6	·397	·076
	„ „ „ . . .	6 to 7	·374	·072
	„ „ „ . . .	9 to 12	·336	·062
4	Plank 2 inches thick, notch 10 feet,	1 to 2	·476	·092
	with wings	4 to 5	·442	·087
7	Overfall with crest	1 to 3	·342	·066
	3 feet wide, sloping 1 in 12 . .	3 to 6	·328	·063
	3 feet long, like a weir . . .	6 to 9	·311	·060
9	Overfall with crest . . .	1 to 3	·362	·070
	3 feet wide, sloping 1 in 18 . .	3 to 6	·345	·066
	3 feet long, like a weir . . .	6 to 9	·332	·064
6	Ditto. Sloping 1 in 18 . . .	1 to 4	·328	·063
	3 feet wide × 10 feet long . . .	4 to 8	·350	·068
14	Overfall, with level crest . .	1 to 3	·305	·059
	3 feet wide × 6 feet long . . .	3 to 6	·311	·060
	„ „ „ . . .	6 to 9	·318	·061

nembers, but they may be purchased from the booksellers' by all who wish to possess the store of practical information they contain.

CHAPTER IV.

THE SOURCES AND SUPPLY OF WATER ITS DISTRIBUTION AND USE AS A MOTIVE POWER.

THE westerly winds which prevail in this country carry with them the clouds, laden with aqueous vapours, rising from the Atlantic Ocean; and, as these clouds strike the ridges of hills on the western side of England, they discharge the greater part of their burden there.

The greatest fall of rain takes place where the lowering rain cloud comes in contact with the hill. Above that point little rain falls, and below it the quantity is diminished until the vapours approach the general level of the ground, when they condense, and the quantity of rain again increases. The observations, made on lofty buildings, show that less rain falls on them than on the ground at their base, and that the quantity of rain falling on the east side of the island is much less than on the west side.

In the west of Scotland, and in some places in the counties of Cumberland, Westmoreland, and Lancaster, a depth of six feet of rain often falls in the course of the year, while, on the level lands of Cambridgeshire, on the eastern side of England, the depth seldom exceeds two feet. The same causes operate on the continent; the western coast receives the greatest amount of rain, and it lessens towards the interior; so that Russia and Austria are dry climates, when compared with Great Britain and Ireland. The average annual amount of rain at St. Petersburgh, including also the snow and hail (when melted), is only 18 inches in depth, during a long series of years.

Mr. J. F. Miller, in his report on the fall of rain in the lake districts of Cumberland and Westmoreland, shows that at Seathwaite, near Derwentwater, 242 feet above the sea, there fell *in eighteen* months, from June 1846, to November *1847, inclusive, 193·69* inches in depth; and, in the same *period, at Styhead,* 1290 feet above the sea, 164·12 inches

body of observers, by whom his instructions were hardly understood, even when he flattered himself he had made them very clear and explicit.

The author has before him a series of tables, the "Collected observations, magnetic and meteorological, made throughout the extent of the empire of Russia, and published annually by order of his Imperial Majesty Nicholas the First." These observations, printed in French, are made by the engineers of the mining corps, at their several stations; and they are so copious and exact, that except the observations made at Greenwich under the astronomer royal, and perhaps those at the universities, few registers kept in England will bear comparison with the Russian tables. The rain-gauge used is composed of two cylindrical vases of copper, placed one above the other, and communicating by a small tube; the upper vessel is open at the top, and is larger in diameter than the under one. The rain water received in the upper vessel passes through the pipe into the closed receiver below, whence it is drawn off by a tap into a wide-mouthed tubular glass measure, graduated in equal divisions. The rain-gauge is filled with water, until it rises in the upper cylinder to a point marked beforehand, and then the water is drawn off by the tap until it has fallen an inch. It is received in the cylindrical measuring glass as it runs out of the lower copper vessel; and if it fill this glass $13\frac{1}{2}$ times, its total capacity being $\frac{1}{13 \cdot 5}$ of an inch, or 0·074 in depth of the upper vessel, it is only necessary to divide the glass into $7\frac{1}{2}$ parts, to show the hundredth part of an inch of rain.

Twice a day the quantity of rain or snow that falls is noted and registered, that is at 8 o'clock, morning and evening; except in case of a heavy shower, when the time, the duration, and the quantity of rain fallen are also noticed, along with the half-day's downfall, and a corresponding remark made.

In winter the rain-gauge is taken into a warm room every twelve hours, to melt the snow or hail received in it, and a second instrument immediately put in its place; every station being provided with two rain-gauges for this purpose.

It is obvious that such instruments as these may be readily managed by private soldiers, and that correct results may be obtained without much nicety of construction, and without much regard being paid to any of the dimensions, except the divisions of the measuring glass.

A very simple apparatus has been found useful by the

author, where a better could not readily be obtained. Let a tin funnel be made in the form of a shallow cylinder, or hoop, of $13\frac{1}{3}\frac{1}{2}$ inches in diameter, equal in area to one superficial foot, and having the bottom conical, with a pipe of small diameter in the centre, say three quarters of an inch or thereabouts: fit this pipe into the neck of a bottle (a stone-ware bottle is better than a glass one), and let it reach nearly to the bottom of the bottle; put in a little water until it rises above the end of the pipe, to close and seal it so as to prevent loss by evaporation, and the rain-gauge is ready for use.

Weigh the whole apparatus and note the weight; then set it to receive the rain that may fall with the bottle sunk in the ground, and as the top or mouth of the funnel is one superficial foot in area, and a cubic foot of water weighs 1000 ounces, every ounce of water received in the bottle is one-thousandth part of a foot in depth of rain fallen.

One of the most approved rain-gauges has a funnel similar to the last, also a foot in area, mounted on a stand-pipe which receives the water, which should be carried down to the bottom by a slender tube trapped with water at the end, and the stand-pipe has a suitable base or foot. The rain received in the pipe is read off by means of a small graduated glass tube fixed to its side and communicating with it. If the stand-pipe's section be one-tenth of a superficial foot in area, and the glass be divided decimally, every inch of water in the glass will indicate one-tenth of an inch of rain; or the glass may be graduated by trial to suit the stand-pipe.

A convenient portable rain-gauge is also made which answers sufficiently well for temporary purposes, and shows the quantity of rain fallen with tolerable accuracy. It is made of japanned tin, something like an ordinary coffee-pot, and is surmounted with a funnel equal in area to one-fourth of a superficial foot. The water it receives is poured into a graduated measuring glass, whose diameter or section is so proportioned to the area of the funnel as to indicate the depth of rain in inches and decimals, or the glass may be marked in the same way as those used at the Russian stations before described.

It is better to use any of these modes than a measuring rod or staff, which often gives incorrect results; and the rain-gauge should be set with the mouth of the funnel exactly in a horizontal plane or level, and not exposed to blasts or *eddies* of wind, nor sheltered from the ordinar

Let it be remembered that in such situations a bed of alluvial soil often rests upon clay, with water oozing between them, and that the beds in such situations slope in the direction of the valley, and consequently in that of the thrust. This is no uncommon case, and unless the greatest judgment and foresight be exercised in forming such dams in the outset, they may sooner or later yield to the enormous force pressing against them, and carry ruin and devastation with them.

The author has seen railway embankments, hastily raised to cross the valley, where an inclined substratum of clay, lurking as it were beneath, intercepted the surface water, and caused an insidious and slippery parting in the measures, slide as if they had been launched, for several yards, and wrinkling up the green sward, to the dismay and loss of the too clever contractors who risked such an experiment. But in making dams to confine water, nothing will justify such risk; and as this little book may fall into the hands of young practitioners in remote places, the author strongly urges that in constructing such works nothing should be left to chance; that well constructed banks with flat slopes, stout puddle walls and lining, earthwork and masonry sufficiently massive to resist unflinchingly the greatest possible amount of thrust they may have at any time to sustain, should be constructed in all cases; that means of relief and discharge be provided to meet extraordinary seasons; and that both surface and substrata be carefully bored and examined before the works are commenced, and diligently watched during their progress, for great responsibility lies upon the man who attempts, with insufficient means, to restrain a destructive and overwhelming torrent.

CHAPTER VI.

HORIZONTAL WATER-WHEELS AND SIMILAR MACHINES.

[HE primitive application of water-power to turn mill-nes has been noticed in the early part of this book, and employment of horizontal water-wheels, with vertical es, is still considered by French engineers to be in many es advantageous, as presenting great simplicity and nomy, both in construction, maintenance, and applica-n; as requiring but little space, and in being able to rk in floods and in frosty weather.

In driving corn-mills they need no toothed-wheel work, d in besieged towns they can be worked at all times hout interfering with the defences, being either placed ogether out of harm's way, or costing but little to shelter em from the enemy's fire.

Such is the opinion of experienced officers of the French illery, and we are indebted to two of them—MM. Piobert d Tardy—for an elaborate series of experiments and an cellent report on the useful effect of the ordinary rizontal water-wheel at present used in France. Those which the experiments were made are at Toulouse, where e two dams (*barrages*) of the Garonne, and the abundance water in the canal of the south, near its discharge into at river, have rendered disposable falls of water sufficient put in motion a great number of corn-mills by means of rizontal water-wheels. These wheels are of two kinds: ose situate on the rivers are called bucket-wheels (*à cuve*), d are similar to what are used at Cahors, at Metz, and her places; those which are placed on the canal are called irl-wheels (*rouets volants*), and much resemble those iich have existed from time immemorial, and are turned the percussion of the water upon curved floats, which e here used instead of the ladles that are fixed round the les of the mills of the Alps.

It may here be remarked that in Northern Africa several de mills are to be found in the same fashion as they have isted for ages, among a people the least advanced in the ts of *industry; many* of them are on the great falls of the

minute, the useful effect was from 29 to 33 per cent., ar
when the resistance of the work done reduced their spe
to 90 and 85 turns per minute, their effect reached to 3

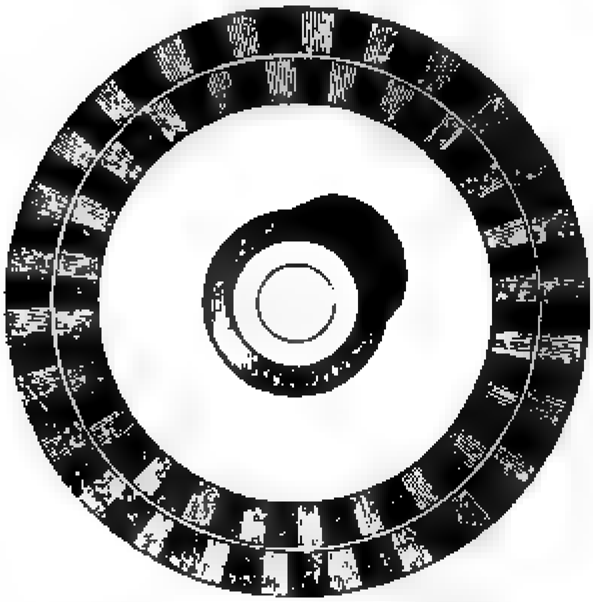
Fig. 9.—Rouet Volant.

and 40 per cent. of the power expended, the useful effect *these wheels being* nearly the same as that of the old und *shot water-wheel.*

Fig. 12.

PLAN OF FIXED PART WITH GUIDE CURVES.

Fig. 13.



PLAN OF REVOLVING PART WITH BUCKETS.

This combination is a great improvement upon the whee at Toulouse, before described; and the same principles ha *been further* developed by MM. Fromont, who obtain

, appears, from experiments made on its efficiency, e of the most successful modifications of that form ed into France by Fourneyron, in place of the old al water-wheel.

is another simple and useful water-wheel used by nch in Guienne and Languedoc, sometimes called *Poire*, or the pear-shaped wheel. It is also a al wheel with a vertical axis; and when the power is not great, the water plentiful, and the means of tion limited, it may often be adopted with advantage. sts of an inverted cone, with spiral float-boards of a ar form, winding round its surface. This wheel on a pit or well of masonry, into which it fits losely, like a coffee-mill in its box. The water, con- y a spout or trunk, strikes the oblique float-boards, en it has spent its impulsive force, it descends along al float-boards and continues to aid by its weight reaches the bottom, where it is carried off by a canal. considerable ingenuity in this contrivance; for the ater being first applied to the upper, or largest part one, strikes the float-boards at the point where ve with the greatest speed, the radius there being but as the water loses its velocity, in consequence notion it has imparted to the wheel, it descends in e and acts upon the floats lower down, where, the eing less, they move more slowly; and the water is eficially employed until it quits the wheel.

perhaps not necessary to describe the Danaide of ot, nor the Conchoidal-wheel of Euler, as neither of e in use, excepting so far as to notice that, in the hese, the water acts in a narrow annular channel, at umference of the machine, formed between a hollow and a solid internal drum, which is also shallower outer one, and that it is projected into this hollow hannel by inclined spouts, or jets forming tangents rcle, so as to drive it round, after which it goes out entre, through passages suitably formed, so as to the effect of the water as long as it remains in el.

signing the conchoidal wheel, the inventor seems to have discovered, the reactionary effect of the water, which has since been made available in the that is to say, the unbalanced pressure opposite to ces, *impels the* wheel somewhat in the same wa

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that a sky-rocket is driven through the air in its rapid flight, by the force or recoil acting against the closed end of the rocket tube or case. It does not appear, however, that this horizontal wheel was ever made practically useful.

CHAPTER VII.

TURBINES, AND THE REACTION OF WATER PRESSURE ON WHEELS, ETC.

Within the present century, a new mode of applying the power of water to produce circular motion has been introduced, and of late years it has attracted much attention, and received many improvements: hitherto it has been but little used in England; but in Germany, in France, and in America, it has been very successfully employed.

It is chiefly to German engineers and mathematicians that we owe the investigation of the principles on which the turbine is constructed, and the best methods of reducing them to practice. The French, also, have been prompt to appreciate the value of the turbine: M. Arago has given his testimony as to its merits, and other French writers of note have examined it in detail; but we have no complete work in the English language, except a translation from the German of Professor Moritz Ruhlmann, edited by Sir Robert Kane, and rendered valuable to practical men by his observations.

In order that the subject of this chapter may be better elucidated, and traced from its first elements, it may be proper to notice the philosophical toy which figures in many works on hydrostatics and hydraulics, as Dr. Barker's mill, but is by most persons passed over as a mere plaything, useless for practical purposes; it involves, however, principles of action which, when well and scientifically carried out, lead to most important results.

Dr. Barker's mill consists of an upright pipe or tube, with a funnel-shaped open top, but closed at the lower end; and from the lower end project two horizontal pipes or arms, also closed at the outer ends, and placed opposite to each other, at right angles with the vertical tube, so as to form a cross. Near to the end of each horizontal pipe, and on

of it, is a round hole, the two holes being opposite
other. The upright pipe is mounted upon an axis or
and is kept full of water flowing into the top.
vater, issuing from the holes on the opposite sides of
izontal arms, causes the machine to revolve rapidly
axis, with a velocity nearly equal to that of the
water, and with a force proportionate to the hydro-
ressure given by the vertical column, and to the area
apertures; for there is no solid surface at the hole
h the lateral pressure can be exerted, while it acts
full force on the opposite side of the area. (See
.)

Fig. 16.

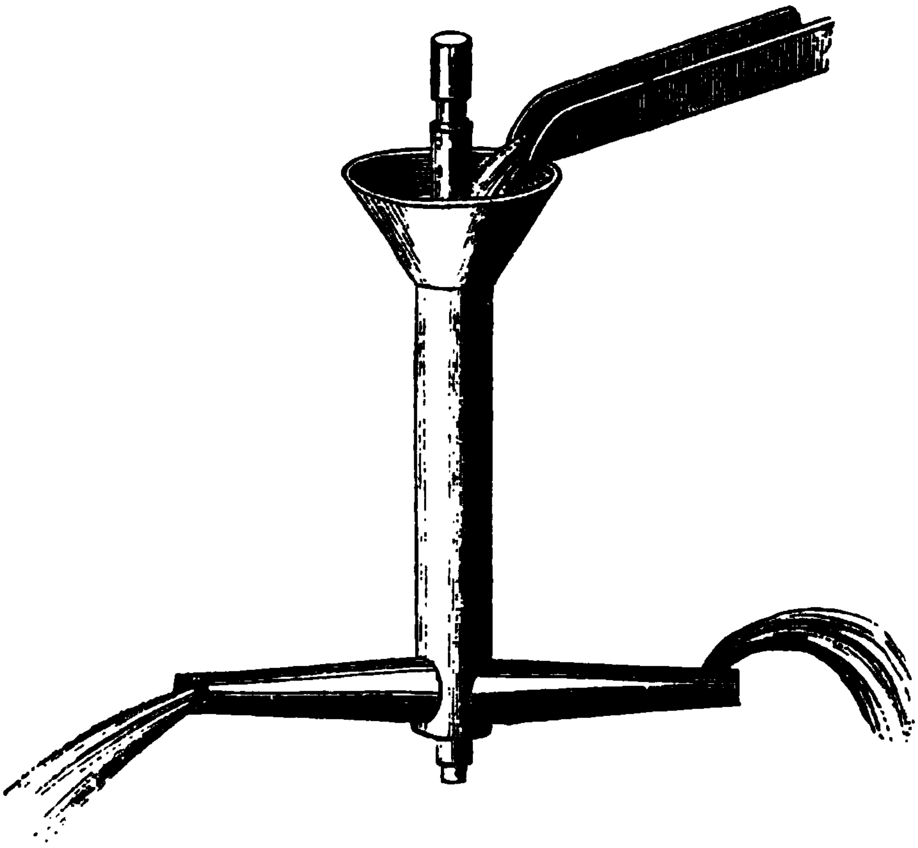
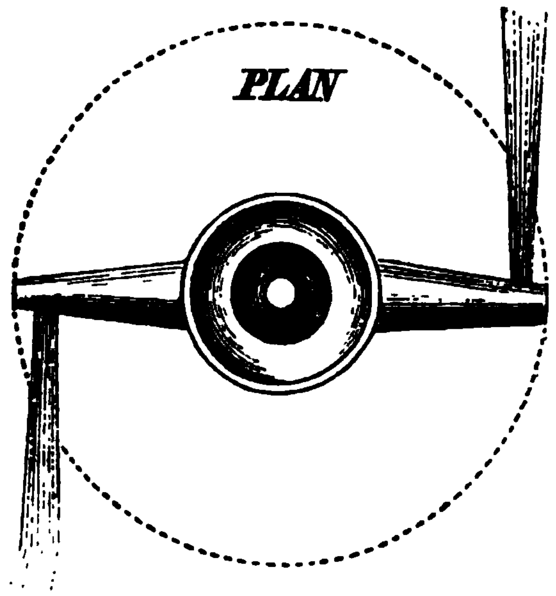


Fig. 17



This unbalanced pressure, according to Dr. Robison, is equal to the weight of a column having the orifice for its base, and twice the depth under the surface of the water in the trunks for its height.

This measure of the height may seem odd, because if the orifice were shut, the pressure on it is the weight of a column reaching from the surface. But when it is open, the water issues with nearly the velocity acquired by falling from the surface, and the quantity of motion produced is that of a column of twice this length, moving with this velocity. This is actually produced by the pressure of the fluid, and must, therefore, be accompanied by an equal reaction.

When the machine, constructed exactly as before described, moves round, the water which issues descends on the vertical trunk, and then, moving along the horizontal arms, partakes of the circular motion.

This excites a centrifugal force, which is exerted against the ends of the arms by the intervention of the fluid.

The whole fluid is subjected to this pressure, increasing for every section across the arm, in the proportion of its distance from the axis; and every particle is pressed with the accumulated centrifugal forces of all the sections that are nearer to the axis; every section, therefore, sustains an equal pressure, proportional to the square of its distance from the axis. This increases the velocity of efflux, and this increases the velocity of revolution; their mutual co-operation would seem to terminate in an infinite velocity of both motions; but on the other hand, this circular motion must be given even to every particle of water, as it enters the horizontal arm. This can only be done by the motion already in the arm, and at its expense. Thus there must be a velocity which cannot be over-passed, even by an unloaded machine. But it is also plain, that by making the horizontal arms very capacious, the motion of the water to the jet may be made very slow, and much of this diminution of circular motion prevented.

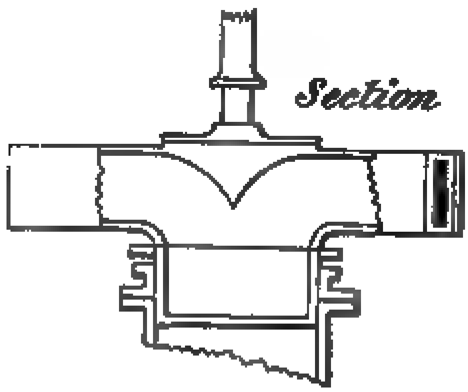
Dr. Désaguliers, Euler, John Bernoulli, and M. Mathon de la Cour, have treated of this machine; and the latter author proposes to bring down a large pipe from an elevated *reservoir, to* bend the lower part of it upwards, and to *introduce into it* a short pipe with two arms like Dr. Barker's *mill reversed,* and revolving on an upright spindle in the *same manner;* the joint between the two pipes being

contrived as to admit of a free circular motion without much loss of water. By this arrangement, a fall or column of water of any height, however great, may be rendered available. This arrangement was proposed in 1775. Some few years ago, Mr. James Whitelaw, of Paisley, attempted the improvement of this machine, and took a patent for his improvement, of which he published an account in 1845. This would seem to consist chiefly of the modifications recommended by Dr. Robison and M. Mathon de la Cour, and of the bending of the two horizontal arms into the form of the capital letter S: the water being discharged from the ends of the arms, in the direction of the circle traced by their revolution, or in that of a tangent to it. The curvature is that of an Archimedean spiral, with the extremity of the arm or jet piece continued for a short distance in a circular curve, coincident with the circle described by the end of the arm. The utility of this continuation, however, seems to be questionable.

The wood-cuts show the method of striking the spiral curves to form the arm and a section of the machine.

Fig. 18.

Fig. 19.



The capacity of the hollow arms is increased as they approach the centre of rotation, so as to contain a quantity of water at every section of the arm inversely proportionate to its velocity at that section, so that little of the centrifugal force may be lost. The engravings show an elevation and plan of Mr. Whitelaw's machine, and the method he proposes for forming the arms. The curvature is that of an Archimedean spiral, with the extremity of the arm or jet piece *continued for* a short distance on a circular curve. *The utility of this* continuation, however, seems somewhat *doubtful.*

The sections of the arms are everywhere parallelog of equal depth, but of breadth increasing from the je the extremity of the arm to the centre of the machine. fig. 20.)

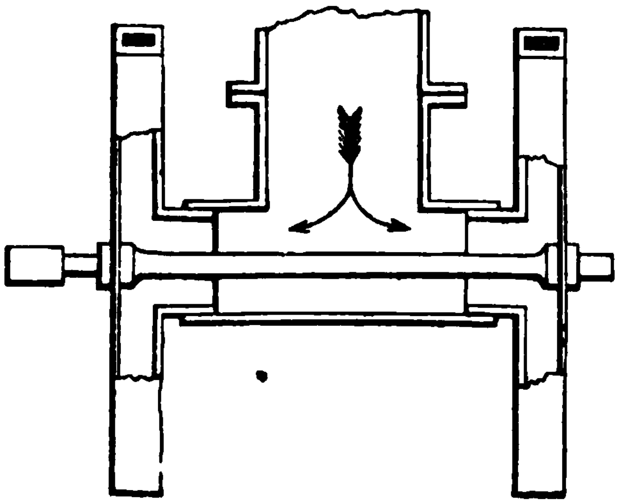
A model water-mill of the form shown in these fig working with a fall of 10 feet, the diameter of the described by the arms being 15 inches, and the apertu each jet 2·4 inches in depth by ·6 of an inch in widtl area of each orifice being 1·44 inches; the expenditu water was 38 cubic feet, the velocity 387 revolution minute, and it gave an effect equal to 73·6 per cent. c power employed.

Mr. Whitelaw states that the machine is most eff when the jets or ends of the arms revolve with a ve equal to that acquired by a heavy body falling througl height of the vertical column.

The model used in this instance was well made an experiments carefully conducted, but Mr. Whitelaw that he has obtained nearly equal results in actual pr on the large scale.

It will be observed that in the employment of wa considerable altitude, a great force will be exerted ag the moving part of the machine, tending to lift it up its seat; it has therefore been proposed by M. Redtenb Professor of Mechani Carlsruhe, to obviate inconvenience when falls are used, by makin axis horizontal and upon it two machine troducing the water bet them by means of a formed like the letter ' that equal pressures a in opposite directions counteract and neut each other.

Fig. 21.



The axis or spindle connecting the two machines passing through the transverse pipe, is kept in a st tension by the di verging forces. (See Fig. 21.)

The author was indebted to Professor Wedding, of B for the first authentic information he received respectin turbine, as also for a sketch and the dimensions of o *these machines*, then recently erected under M. Wed

direction. The fall, or rather the head, of water acting upon it was 20 feet, the diameter of the wheel 3 feet 8 inches, the speed 115 revolutions per minute, and the power equal to 42 horses, which drives eight pairs of ordinary millstones, with all the requisite dressing machinery. Professor Wedding afterwards sent the author from Berlin a treatise on this subject which he had written in conjunction with M. Carliczeck, wherein several other similar machines are described, and the useful effect of the water is stated at from 68 to 80 per cent. (See Fig. 22.)

It will be seen that the great value of the turbine consists in its being applicable to falls of water so high or so low that an ordinary water-wheel cannot be used; and also that in falls of great height the velocity of the machine is so rapid, that when applied to drive spinning machinery, it needs no mill work, or but very little, to bring it to the requisite speed.

The invention of the turbine, properly so called, belongs to M. Fourneyron, and in its present form it generally consists of a horizontal water-wheel, in the centre of which the water enters; diverging from the centre in every direction, it enters every bucket at once and escapes at the circumference or external periphery of the wheel. The water acts on the buckets of the revolving wheel with a pressure proportionate to the vertical column or height of the fall, and it is led or directed into these buckets by stationary guide curves, placed upon and secured to a fixed platform, within the circle of the revolving part of the machine. The efflux of the water is regulated by a hollow cylindrical sluice, to which a number of stops, acting simultaneously between the guide curves, are fixed.

With this short cylinder or hoop, they are all raised or lowered together by means of screws communicating with a regulator or governor, so that the opening of the sluice and stops may be increased or diminished in proportion as the velocity of the wheel may require to be accelerated or retarded.

This cylindrical sluice alone might serve to regulate the efflux of the water, but the stops serve to steady and support the guide-curves and prevent tremor.

Turbines may be considered as divided into two classes,—the low pressure and the high pressure. The engravings will better explain the construction of these machines and *the arrangement* of their parts than a longer verbal de*scription.*

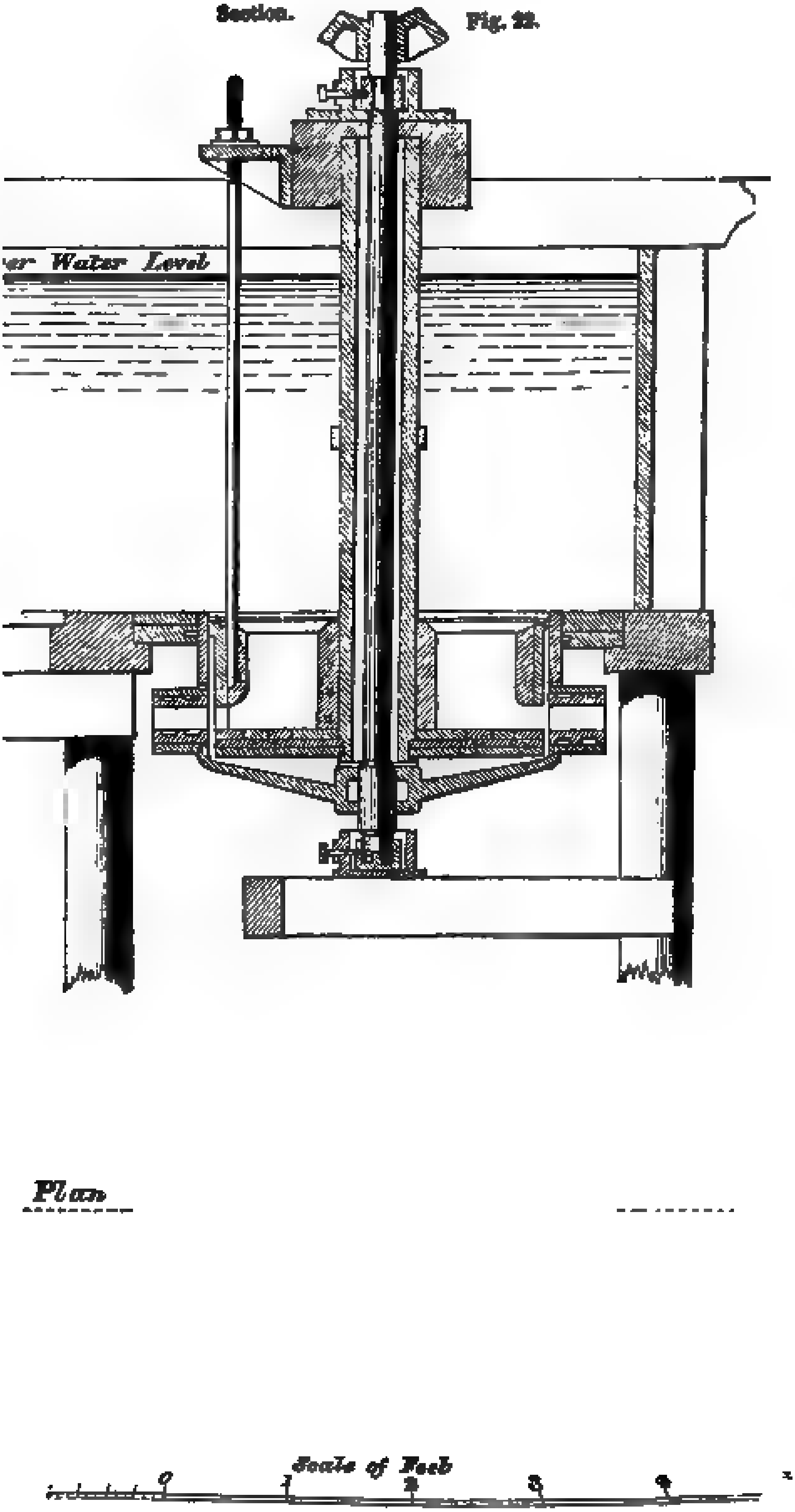


Fig. 22.

ensure a constant supply, where the height of the column of water may compensate for the smallness of its volume. In such situations it may be conveyed in pipes to the high-pressure turbine, which may often be applied with advantage for grinding corn, working threshing machines, or for crushing ore, and other purposes. There are other situations in which a great volume of water rolls, with but little fall, and it has been shown that, with a head of only nine inches, the low-pressure turbine has done good service.

The illustrations here given, as explanatory of the progress and construction of the turbine, are an elevation and plan of Dr. Barker's mill; an elevation and plan of Mr. Whitelaw's mill; and diagrams, showing the method of striking the spiral curves to form the arms; with a section, showing how the mill is connected with the supply-pipe; the loose collar is pressed upwards against the revolving part of the machine by three bow springs, fixed between the flanches; the collar is prevented from revolving, by a steady pin; and the parts in contact are ground together to be water-tight.

A sectional elevation of a low-pressure turbine, with one of the three screws for raising and lowering the circular sluice (with plan). The screws are connected, and act together, by means of toothed wheels. (See fig. 22.)

Also a plan of the water-wheel, the guide curves, and a portion of the circular sluice. The curved buckets, which are made of thin plate-iron, are screwed against loose blocks or pieces of cast-iron; and these are secured, by means of screw-bolts, within the rim of the water-wheel.

The turbine of St. Blasier, shown in section. The body of the machine is of cast-iron; the wheel is of hammered iron; and the spindle, or axis, of steel. (See Fig. 23.) The letters refer to the same parts on plan. (See Fig. 24.)

The foot of the spindle, and the pivot and step on which it revolves, are tempered to extreme hardness. The oil-pipe at the foot of the pivot is connected with a small force-pump, or syringe, which, at regular intervals, injects a little oil into the step for lubrication. The pump is worked by a slow motion from the machinery.

In all cases it is necessary that the foot of the spindle shall be made hollow, and run upon a fixed pivot. The spindle must never run in a hollow step. The pivot should be quite cylindrical, and it should truly fit the spindle, with *as little play* as possible; the top of the pivot should be but

very slightly convex. The water and mud must be carefully excluded, and the parts regularly oiled.

A quadrant or fourth part of the wheel, with the guide curves, and the sluice or regulator of the turbine of St Blasier. This engraving is one-half of the natural or full size of the machine itself; the bent arrow shows the direction in which the wheel revolves.

Fig. 24.

There is also another difference in the construction of turbines which should be noticed. Some have been made which receive the water at their circumference and discharge at their centre. Several of these have been erected in the United States, and have worked very well; but the amount of duty done by a given quantity of water is not so great as when it is admitted at the centre and escapes at the circumference, where it can do so more freely. It is therefore unnecessary to go very minutely into the details of this *machine, which* is like Mr. Appold's centrifugal pump, so

CHAPTER VIII.

UNDERSHOT WATER-WHEELS, THEIR USEFULNESS IN A NEW COUNTRY TO SAW TIMBER, ETC.

THE primitive form and use of vertical wheels for raising water for the irrigation of land in China and the East, has been already noticed. These, simply dipping their floats into a river, were turned by the current with such velocity and force as the stream might impart to them.

Yet, before quitting this part of the subject, it may be proper to mention two modes of applying these wheels which have been practised in America.

One of them was to place a strong axle across a boat, or some other vessel, of large dimensions, with a water-wheel at each end of this axle, like the paddle-wheels of a steam-boat; and this vessel being moored in a current, the wheels revolved, and gave motion to mill-stones, and machinery for grinding and dressing flour, on board the floating mill. The other was by means of a similar axle and a pair of wheels, thus mounted in a boat, to cause the boat so fitted to warp itself, and to tow other boats up a rapid, by winding one end of a rope round the axle, the other end being made fast to an anchor, or other mooring, above the rapid. This means of ascending rapids in the American rivers has been generally superseded by the employment of powerful steam-boats; but it is worthy of being recorded as an ingenious contrivance to derive from the resisting medium itself a power to overcome it, by duly proportioning the diameters of the wheels and axles.

The next improvement was an important one; and it rendered the vertical water-wheel a powerful mechanical agent.

By penning back the stream with a dam or barrier, thrown across its channel, so as to accumulate and raise the water to a head; and by cutting a canal, or water-course, in the bank, communicating with the reservoir so formed, *and re-entering* the river by its side at a lower level; by *erecting the wheel* in this water-course, and by interposing

sluice between the wheel and the pent-up water, so as to top or regulate its efflux, the whole power of the water, eretofore spread over the bed of the river, might be conentrated against the wheel, rushing through the opening of he sluice, with a velocity and impulse due to its head and olume, and acting upon the float-boards with an amount of orce and effect which could not be obtained in the open iver; the water being now confined between walls of solid nasonry almost in contact with the wheel, and within which t revolved.

These walls also served to support the axis of the wheel, nd to retain the sluice; while a pavement of heavy stones elow, between the walls, prevented the water from escaping eneath the wheel until it had done its duty.

When the sluice was shut down and the wheel stood still, ntil the dam was filled to overflowing, the water passed ver the barriers or weir, and rolled on, as before, through s old channel in the river, or was discharged into it through waste-water sluice, sometimes made self-acting by means f a balanced float, or some similar contrivance; and, on dapting such apparatus, great ingenuity has often been isplayed, especially in the Shaw's Water-works, already entioned, as well as by some of the French engineers.

Arrangements like these, so simple, so effective, and so asily made and managed, rendered the UNDERSHOT-WHEEL ost useful and valuable as a means of obtaining mechanical ower sufficient to drive extensive flour-mills, fulling-mills, nd forges, for which purposes it was, in the first instance, hiefly used, to aid an agricultural population in more eadily supplying themselves with bread, woollen cloth, and on—the principal requirements of a primitive community, ith whom spinning and weaving were as yet domestic mployments.

The sluice, which regulated or closed the opening through hich the water issued against the wheel, was placed as low s possible, allowing only sufficient fall or space for the scape freely after it had passed the wheel, so that it might ot, as a millwright would say, "be working in back water." he opening, or the sluice, corresponded in size, or nearly o, with the width of the float boards of the wheel, and e head of water above it caused the stream, or rather the t, to strike the float-boards with a proportionate momentum, e wheel receiving, as it were, a succession of impulses as e float-*boards continually* entered the water.

then by assisting it by means of counter-weights or cord wound round the axle, until the velocity of the wheel is identical with that of the water and the counter-weight, equal to friction and resistance of the air; for, if it were too little, the water would accelerate the wheel beyond the weight; and if too great, retard it; so that the water becomes a *regulator* of the wheel's motion, and the velocity of its circumference becomes a measure of the velocity of the water. The velocity thus determined, the virtual or effective head may be determined by the law of gravitation; and although, as Mr. Smeaton observed, the virtual head bears no certain or definite proportion to the actual head—as indeed has been shown in a foregoing part of this book—yet, when the aperture is greater, or the velocity of the water issuing therefrom is less, they approach nearer to a coincidence; and consequently, in large openings of mills and sluices, where great quantities of water are discharged from moderate heads, the actual head of water and the vertical head, determined from the velocity, will the more nearly agree, as experience confirms.

From the numerous experiments he had made on the undershot-wheel, Mr. Smeaton deduced the following rules, or, as he calls them, maxims:—

"1. That the virtual, or effective head, being the same, the effect will be nearly as the quantity of water expended.

"2. That the expense of water being the same, the effect will be nearly as the height of the virtual or effective head.

"3. That the quantity of water expended being the same, the effect is nearly as the square of its velocity.

"4. The aperture being the same, the effect will be nearly as the cube of the velocity of the water."

Upon comparing the several proportions between *power* and *effect*, remarked during the course of his experiments, Mr. Smeaton observes, the most general is that of 10 to 3, the extremes 10 to 3·2 and 10 to 2·8; but as it appears, that where the quantity of water, or the velocity thereof, that is, where the power is greatest, the second term of the ratio is greatest also, we may therefore well allow the proportion subsisting in large works as 3 to 1.

He also observes, that the proportions of velocity between the water and the wheel are contained in the limits of 3 to 1 and 2 to 1; but as the greater velocities approach the limit *3 to 1, and* the greater quantities of water to that of

2 to 1, the best general proportion will be that of 5 to 2. He endeavoured to ascertain what is the ratio between the load such a wheel would carry at the maximum of effect, and what will totally stop it, and found that it would work steadily until that proportion was as 4 to 3; but when this limit was exceeded, the whole worked irregularly, and was liable to be stopped.

The principal aim, however, of a good millwright, is to make the wheel work to the greatest advantage; and the last-mentioned experiments were therefore more curious than useful; yet they are highly interesting, as they make the investigation complete, and anticipate a question which might very naturally be asked.

Mr. Smeaton mentions, that in his working model of an undershot water-wheel, the maximum load was equal to 9lb. 6oz., and that the wheel ceased moving with 12lb. in the scale; to which, if the weight of the scale is added, nearly 10oz., the proportion will be nearly as 3 to 4, between the load at the maximum and that by which the wheel is stopped: and he says,—

"It is somewhat remarkable, that though the velocity of the wheel, in relation to the water, turns out greater than one-third of the velocity of the water, yet the impulse of the water, in the case of a maximum, is more than double of what is assigned by theory; that is, instead of four-ninths of the column, it is nearly equal to the whole column."

It must be remembered, that in the present case the wheel is not placed in an open river, where the natural current, after it has communicated its impulse to the float, has room on all sides to escape; but in a conduit or race, to which the float-board being adapted, the water cannot otherwise escape than by moving along with the wheel; and when a wheel works in this manner, as soon as the water strikes the float it receives a sudden check, and rises up against the float, like a wave against a fixed object; so that in the working model, when the sheet of water was not a quarter of an inch thick before it met the float, yet this sheet acted against the whole surface of a float three inches high; and, consequently, if the float were no higher than the thickness of the sheet of water, a great part of the force would be lost by the water dashing over the float.

Although in this country the value of water power, and the necessity to make the most of it, has gradually caused the *undershot wheel to* be abandoned, and the breast wheel

to take its place, whereon the gravity or weight of the water acts instead of its impulse; yet there are many purposes to which the undershot wheel may be applied with

Fig. 26.

advantage, and to none more than the sawing of timber, especially in new settlements, and in those localities where water power is abundant and mechanical skill is scarce *where labour is* expensive and timber costs nothing. In

such circumstances, a simple and efficient saw-mill is of great advantage, and it may be worked at once from the axle of the undershot water-wheel, working two saw frames, by means of cranked arms upon the ends of it; or, if the axle be made of iron, a crank may be formed in it to work a single saw frame, as shown in the annexed woodcut, reduced from an engraving in the Professional Papers of the Royal Engineers, vol. vi., in which will also be found a minute description, elaborately illustrated, of the saw mills and machinery for raising timber in Chatham dockyard, erected by the late Sir Mark Isambard Brunel. (See fig. 26.)

In this engraving A is the dam, frequently formed of square logs, resting against a standard secured by struts, provision being made to carry off the surplus water. B is the sluice, which, being raised to work the wheel, admits the water into the trough C; here it strikes the float-boards of the wheel D, which is generally made of small diameter, so that the velocity of the water may cause it to make as many revolutions as possible, consistent with the requisite power; the saws making as many strokes as the wheel makes revolutions. E, the crank on the wheel shaft, to which is adapted the connecting rod F, which is attached to the bottom of the saw-frame G. This slides up and down between the standards with an alternating motion, the strokes being double the length of the crank arm. K is the log to be cut; it is mounted on the frame L, which has a rack fixed in its under surface, and is supported by the rollers *a a*.

The pinion *b* on the axis of the wheel M works in the rack, and according as the wheel moves forward or backward, it works the frame, moving it towards or away from the saws. Motion is given to this wheel by the pall *c*, the other end of which is jointed to one of the sides of the arm of the bent lever *d*. This lever is moved backward and forward by the rod *e* which is jointed to the bent rod *f*, and this rod, or rather lever, is fitted upon an axle attached at one end to the frame of the wooden building and at the other to the frame of the saw-mill. When it is requisite to reverse the motion, after the log is cut, the pall *c* is lifted clear of teeth of the ratchet-wheel M; and this wheel is turned in an opposite direction by hand.

A saw-mill on this principle was made by the late Mr. Rennie, of which he has given the following brief

description: it appears to have been driven by the water of Leith. The diameter of the wheel was 4 feet 6 inches, and its width 3 feet 2 inches. The floats were 12 inches deep, and were inclined in direction 4 inches past the centre.

The cranks had 11 inches radius; there was one on each end of the water-wheel axle; consequently the saw-frames driven by them had 22 inches stroke. The one frame had five saws and the other frame two saws; they made 13·6 strokes to cut one inch forward.

The fall of water was 3 feet 7 inches, and it was conducted in a sloping direction, in such a manner as to be nearly a tangent to it; the perpendicular height of all being 3 feet 7 inches, and the horizontal distance 8 feet.

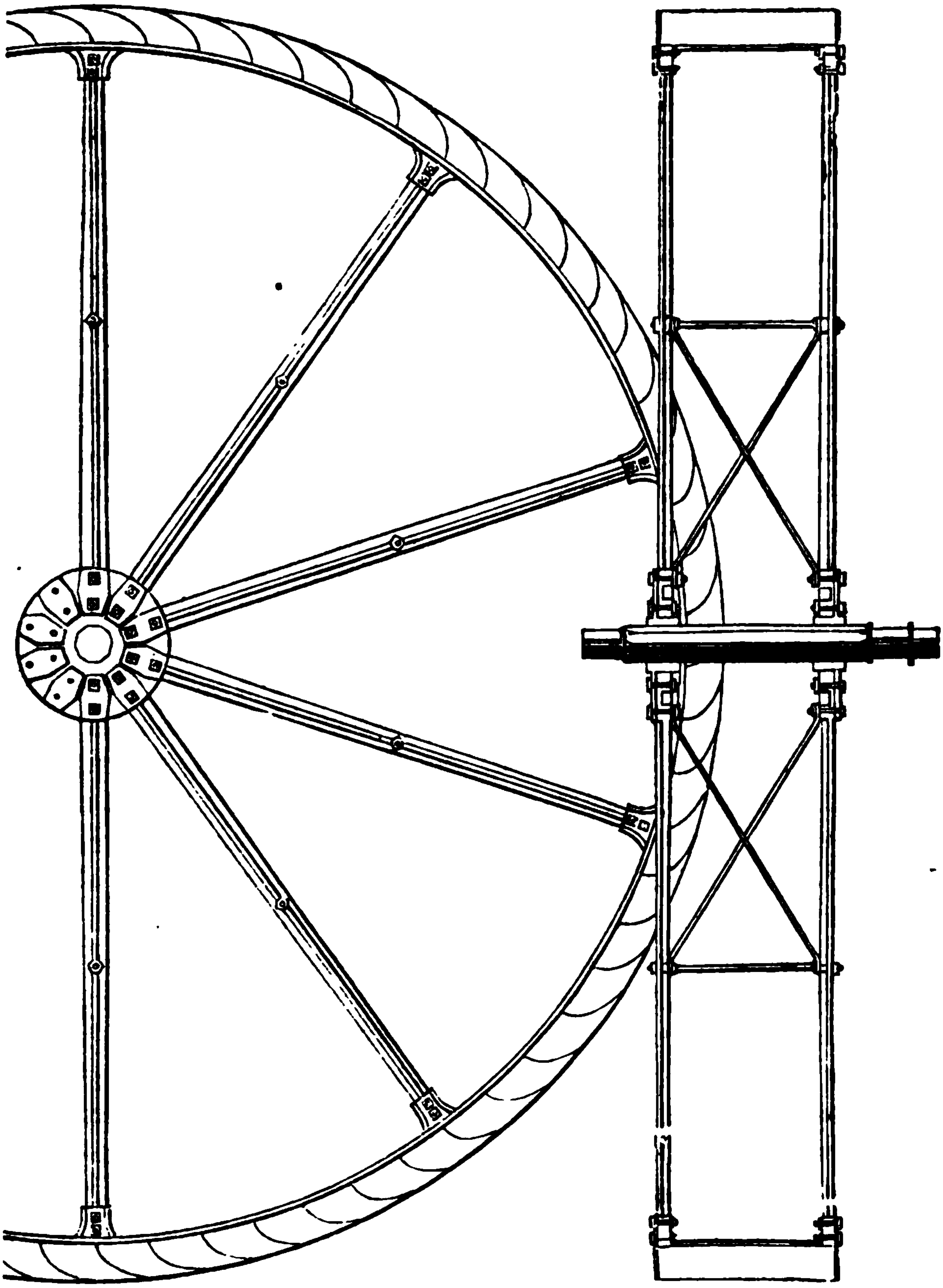
The sluice was 3 feet 2 inches wide, and was raised to the surface of the water, namely 18 inches, at the head of the slope where it was placed. The sluice being raised to the water's surface, the wheel made fifty-eight turns per minute, working the seven saws. The timber cut was Norway fir; in the frame with five saws it was 8½ inches deep, and in the frame with two saws it was 6 inches deep, so that in one minute it cut 4·26 inches forward. It is to be observed, however, that in such small wheels there is a considerable loss of effect, when compared with wheels of larger diameter; and accordingly Mr. Rennie states the performance of another saw-mill, at Dartford, which, with the dimensions, he tabulates as follows:—

DARTFORD SAW MILL.

1. Water-wheel 16 feet diameter.
2. Breadth 4 feet 6 inches, depth 1 foot 3 inches.
3. Fall 2 feet 3 inches, head 2 feet 9 inches.
4. Spur-wheel, or inner end of shaft, 64 cogs.
5. Pinion on crank 18 cogs; thus the crank made 3·55 turns for one turn of the water-wheel.
6. Throw of crank 10 inches.
7. Slabbing-saw made 34 strokes for 4 inches advance of timber.
8. Deal-saw made 19 strokes to 1 inch advance.
9. Frame of saws 4 feet wide inside; saws 5 feet 3 inches long.
10. Ratchet-wheel 6 feet diameter.
11. Teeth of saws ¾ of an inch asunder.
12. Space taken out by saw ⅛ of an inch.

m every part of the work will be increased in proportion. . Smeaton's experiments showed that the best effect was ained when the velocity of the wheel's circumference was ittle more than three feet, or a second; and hence, it

Fig. 28.



:ame a general rule to make the speed of the overshot ter wheels at their circumference $3\frac{1}{2}$ feet per second, or 0 feet per minute.

Experience showed this velocity to be applicable to the

Fig. 29.

iful head above the orifice to produce a jet flowing with desired speed; and the under hatch being raised or ered by racks and pinions, the thickness of the stream vered upon the wheel, was diminished or increased at

Fig. 32.

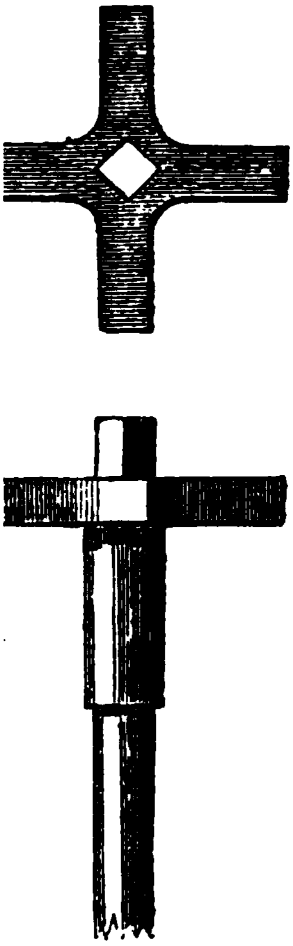
WATER-WHEEL AT WALTHAM ABBEY.

›yed in the actual grinding of the corn. This gives a ›rtion of ·714 to 1, or somewhat over 71 per cent. of l effect.

·. Fenwick, who was of an ancient family in Northumber- was by profession a "colliery viewer;" he had a reputation for mechanical and engineering skill, and ıving in the schooldays of the author; he wrote several ı on practical mechanics and mining, which were at time esteemed as good authority and went through ıl editions.

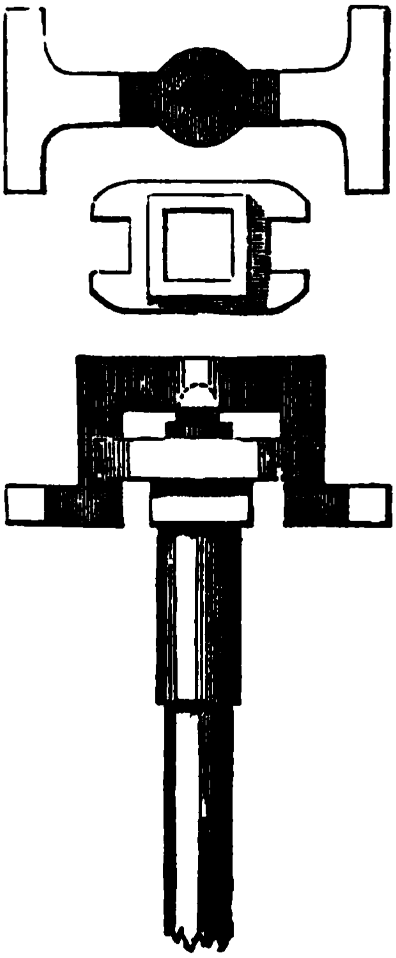
does not state what kind of mill-stones were employed, robably they were the "Dutch blue stones" then in , kind of lava rock, wrought chiefly in the German ies near Andernach and Coblentz, brought down the ɜ and shipped to this country from Holland. They had seded the mill-stone grit or "grey stones" as they ɩave since been displaced by the "French burr stones," ;enerally employed in grinding wheat. The blue stones ıt little used, and the grey stones are seldom seen,

Fig. 40.



e fixed cross or rynd.

Fig. 41.



The bridge rynd.

t in the north for grinding oatmeal, rye, or barley. These blue stones were each in one piece, and were

ppear as a funnel of sheet-iron, with which the old miller ad no sympathy.

The iron apparatus for adjusting and securing the millones, involved an iron frame and columns to carry it, nstead of wood, and hence many mills of recent date have een built fire-proof. For such cases stone foundations and ooring have become requisite, and the mill-spindles, instead f being stepped upon the middle of the foot-bridge, a lever f wood fixed on a joint at one end, and regulated at the ther, between the timber uprights carrying the millstone oor, has been brought down to a cast-iron pedestal resting n the masonry, and containing within it a compact combiation of wheels or levers and screws, by which the space etween the millstones may be altered at pleasure.

It has been proposed to use annular millstones, by emoving the central part, where little work is done, and eplacing it with a plate of iron leaving the skirt, or as it ere a ring of stone; no practical examples of this kind ave come under the author's observation, except so far as ne of the conical corn-mills partakes of this character, but his must be described separately.

There are three modes of driving millstones at present n use.

The first was suggested by the use of the undershot ater-wheel, which, revolving rapidly, required but one ncrease of speed, and one change of motion from the horiontal shaft to the vertical spindle, and consequently only ne pair of wheels, namely, the face-wheel or pit-wheel on he water-wheel axis, and the lantern-wheel or trundle on he mill-spindle; all the machinery being made of wood xcept the pivots of the axle and the mill-spindle.

This simple, but efficient arrangement, may still be useful n remote settlements, where neither capital nor labour are bundant. It was the usual plan of a mill during the reater part of the last century, and the works of most riters on mechanics and mill-work of the time contain ables showing the number of cogs in the wheel, and staves r rounds in the trundle, to drive a 6-foot millstone sixty evolutions per minute. The cogs and rounds of wood have iven place to bevelled wheels of cast-iron, but the principle *emains the same.* By this means any number of millstones *ay be placed* in a straight line, or in two lines parallel to *h other,* each millstone requiring a pair of bevelled *els, one of* the wheels (the largest) having wooden teeth.

just entering into business, who assisted in planning them, and under whose direction they were executed.

"The engines and mill-work were contained in a commodious and elegant building, designed and executed under the direction of the late Mr. Samuel Wyatt, architect."

Such was the fate of the first great steam-mill erected in London little more than sixty years ago, in which the talents of Watt and Rennie were combined. The year 1852 has witnessed the completion of an undertaking—"The City Flour Mills,"—which may be termed a flour manufactory rather than a mill, built near Blackfriars Bridge, and within sight of the spot where the "Albion Mills" were erected—an enterprise which, if successful, as it promises to be, will effect great changes in this branch of industry.

The present cotton mills in Manchester are scarcely more unlike the old system of hand-spinning, than is this building as compared with the picturesque water-mills we were accustomed to see in our young days. It has two engines working together on one shaft; they are large "steam-packet" engines, each of 125 horses' power, or, together, 250. There will be 60 pairs of millstones, all of them 4 feet in diameter, and making about 128 revolutions per minute; the upper millstones have hollow backs, and a blast is sent into them; thence it passes through the eye and through holes in the top stone; the air quickens the grinding, and makes the stones work cool. The millstones are placed in two rows, one against each side wall, on one floor. The flour is received in covered metal troughs, in which endless screws work the meal along into boxes, to be carried away by the Jacob's ladders or elevators.

The dressing-machines are hexagonal, and are covered with silk; they are 3 ft. 4 in. in diameter across the angles, and 34 ft. long, and have a slight inclination, about 20 inches in their whole length, and are driven at about 28 or 30 revolutions in a minute. The shafts of these machines are hollow, and have also holes through them; but the lower half of the shaft is closed; a blast is driven into the upper end of the hollow shaft, and blows through the holes into the inside of the dressing-mill, for about half its length, and through the silk, so that it cools the flour, cleans the silk, and quickens the action of dressing.

There are some wire machines for brushing the bran, but all the flour is dressed through silk, the chief object being *to make fine flour*. There are, besides corn-cleansers, also

. blast, somewhat like those already described, and ickles, worked by belts, many of which are double- , at every point where they can be made useful, so ıanual labour may be economised at every stage of ›rk by the intervention of mechanical power.

the millstones and most of the machines are driven by which lessen the noise considerably, and much in- y is displayed in their application to prevent lateral on the necks of the mill spindles and to obviate the ›bjections to belts before mentioned: the spindles are and have no foot-bridges, each being stepped on a

Fig. 47.

› waste air trunk carrying up the dust or stive.

› meal spout.

ar or ring of leather to confine the air brought in by a flexible pipe.

ked end of the lever to regulate the supply of corn to the millstones. The arrows show the course of the air.

pillar, containing a regulating screw, and the upper are hung, like a mariner's compass, on gymbal rings, refully balanced: so that altogether it may be said › *flour factory* rather than a corn-mill; and in order

that nothing may be wasted, exhausting-fans are app
the millstone cases, producing a slight draft of air su
to collect and deposit in a proper chamber, the d
"*stive*," as millers call it; but not strong enough t
up the meal. This also keeps the mill cleaner, a
stive, which is finer than flour, can be made useful
author is much indebted to Messrs. Swayne & Bovi
have designed and erected the machinery of this m
their readiness in affording him information and ac
all times to this magnificent establishment.

Mr. Bovill proposes to apply blowing and exhausti
to ordinary millstones already in use, without makin
through them, by sending the current of air throu
millstone eye to be discharged at the circumference,
collect the dust or "stive" from the millstone cases
exhausting-fan, and prevent its flying about the
carrying it up through an air-trunk, and dischar
into a chamber of lattice-work lined with bunting o
similar thin woollen cloth, permitting the air to esca
retaining the dust. The annexed woodcut shows th
posed arrangements. (See fig. 47.)

CHAPTER XIII.

THE CONICAL MILLS.

Of the conical corn-mills exhibited in the Crystal
there were two which more particularly claimed att
One of these was a cone, or rather a conoid of st
peculiar form, base upwards, which fitted, or nearly s
a block of stone hollowed out to receive it, and in w
revolved, like the ancient "*quern*," or like the old mill
at Pompeii reversed; for in that antique mill, the c
conoid stood fixed upon its base and the stone
revolved, but in this modern adaptation, the case i
and the conoid turns.

The form given to this millstone was also recomm
by the exhibitor as applicable to the pivots or st
upright shafts, screw propellers, turbines, and other
nism where the revolving surface must resist vertica
or end thrust.

The inventor proposed to exhaust the air from below the illstones by means of a ventilator or fan, and thus to draw wn a current between the stones to keep them cool. ere was much ingenuity displayed in various contrivances out this mill and its adjuncts; the trouble and incon-

Fig. 48.

MR. SCHIELE'S MILL.

RULER

Mode of striking the curve to form the millstone or pivot.

nience occasioned by the cutting and heating of steps and *ots subject to* end pressure, even in an ordinary lathe, *well known,* and should the mill itself not prove ac

successful in practice for grinding corn as the inventor expects, it may answer well in grinding painters' colours; the form of step he recommends may in many cases be useful to lessen the friction of machinery. Mr. C. Schiele of Oldham, near Manchester, is the proprietor of this mill, and the curve he has adopted is one discovered by Huygens, in his investigation of the cycloid. It is one of those singular and beautiful curves called "tractories," and in this case it is produced by drawing the centre point of a radius bar along a straight line, which is the axis of the curve. The radius bar carries a pen, the nib of which is in the line of the radius. At the commencement of the curve, the radius is at right angles with the axis, but the radius bar, turning freely upon the centre point, as it is drawn along the straight line or axis, the angle it makes with this line varies continually, becoming more and more acute like the tangent of a catenary or a parabola. Dr. Peacock has shown that the mechanical tractory of a straight line, upon a perfectly smooth plane, is an inverted semi-cycloid; but, in this case, the retardation produced by the pen and paper causes the curve to be infinite, and from its peculiar properties it has been termed "the equitangential tractory." (See fig. 48.)

The conoid is formed by this curve revolving on its axis.

The other conical flour-mill, which deservedly attracted much notice in the Exhibition, was the invention of Mr. W. Westrup, a practical London miller. It differed entirely from any other flour-mill hitherto used, and the author availed himself of all the opportunities the display in the Crystal Palace permitted to examine its mechanism and arrangements; he has since seen it at work, and also in pieces, the proprietors liberally affording every facility for the inspection of all the parts in detail. Each mill, so to speak, has two pairs of millstones combined, working together, the one pair placed above the other, so that the upper pair commences the grinding process, and the lower pair completing it; there is a space between the two pairs of millstones about 27 or 30 inches in height, and the greater portion of this height or space is used as a vertical dressing-mill, the spindle which drives the stones being fitted with brushes, and the space inclosed with a cylindrical screen of fine wire-cloth mounted on a frame in the usual way. The upper millstones are fixed, and the lower stones revolve, *and both* the upper and lower stones are placed upon one *spindle*. The upper stones are each made in two parts, or

micircles bolted together, for convenience of fixing and splacing when needful, and they are capable of adjustment · means of fixed wedges or inclined planes, on which they st, so that by the action of a screw and wheel a partial rizontal turn or twist of either of the upper stones, causes to slide up or down on these bent wedges or inclined anes which are placed round the circumference of the one. It is thus raised or lowered, and the grinding space justed with great facility. The lower millstones, which volve, are convex, and the upper stones concave and nular; for the stones being of small diameter the eye of e stone is large in proportion. The diameter is about feet 6 inches, and the grinding surface on each side of this ng of stone 8 or 9 inches broad; the rise or bevel of the ne in that width is about 4 inches. The stones being nall, necessarily revolve rapidly, say about 250 revolutions r minute, and the spindle being hollow from the top, a pe is fitted into it by a swivel-joint, and a blast of air iven by a fan is carried down the spindle, which is closed the lower end, and distributed through holes in the nning stones into the grinding space, so that the meal is mediately blown out, and the grinding surfaces kept clear. he finest flour is brushed through the wire-work of the rtical cylinder, and received in a casing of wood. The rger particles and portions of the corn imperfectly ground, ass into the lower pair of stones, and are reduced into eal ready for dressing in the ordinary way.

As by this arrangement of parts the corn cannot be livered into the centre of the upper millstones, a hopper · chamber is placed on one side, with a sliding tube or feed-pe in the top of it, and an upright spindle carrying a dish, hich revolving quickly, evenly distributes the corn. This scription will probably enable the reader to understand e annexed engraving, which is copied from a section tained from the inventor. (See fig. 49.)

The manner in which this mill does its work is very tisfactory. The corn is so short a time in passing through , that the bran is delivered in large flakes, many of them arly the entire skin of the wheat, and the grinding being so ickly done the meal comes away comparatively cold. The ne flour driven through the intermediate dressing-case is e heart or kernel of the wheat, and is suited for pastry or nfectionary.

There is a vertical dressing-mill separate from the mill-

References to Mr. Westrup's Conical Mill. (See Woodcut.)

A, Feeding-pipe to supply corn to the millstones.
B, Apparatus to regulate the supply.
C, Regulating lever to adjust the same.
D, Chamber over the eye of the millstone to receive the wheat from the regulator.
E, Top stone in the upper pair of millstones which in this mill is stationary.
F, Nether stone of the upper pair which in this mill revolves.
G, Top stone (stationary) of the lower pair.
H, Nether stone (runner) of the lower pair.
I, Hollow spindle on which the runners or revolving millstones are hung.
K, Bevelled wheels and driving-shaft.
L, Iron framework sustaining the whole machine.
M, Upright wire cylinder acting as a partial dressing machine.
N, Revolving brushes acting against the wire.
M, O, Wooden case enclosing millstones and wire cylinder, to the bottom of which the spout for the meal is fixed.
P, Pipe to convey cold air to the faces of the millstones by means of the hollow spindle.
Q, Regulator for adjusting the upper pair of millstones.
R, Regulator for adjusting the lower pair.

tones, in which the flour is finished for the market, and here has been much ingenuity exercised in contrivances to bviate the inconveniences incident in general to the per-endicular cylinder. The axis carries a series of shelves or ables, which in succession receive the meal and scatter it by heir centrifugal action; but it is questionable whether any eal advantages are obtained by carrying the inclination of he dressing-mill beyond the angle of 45 degrees, for at hat angle, with a high speed for the brushes, the meal must lescribe a spiral track of several revolutions in traversing he length of the cylinder, and the adaptation of hoppers, vith moveable partitions before described, is of great ractical convenience.

The inventor of this conical mill has induced several gentlemen to join him in order to carry out his plans to a greater extent than he could hope to do individually, and to orm themselves into a joint-stock company. They entertain, n many respects, similar ideas on the manufacture of flour vith *the proprietors* of the large steam-mills already noticed, *amely, that flour,* like cloth, is a manufactured article of *neral consumption,* and that by manufacturing on the

large scale, with machinery to do the work, and me direct its operations, rather than to labour in the mill, shall be able to supply the flour to the consumer at a l price with a fair profit for themselves; they also think the inventions of Mr. Westrup will better enable the realise their views, and it is but right to say, that se persons have embarked in this undertaking—"The Cc Flour-mill Company"—who are known as men of exper and skill in this branch of industry.

These gentlemen say—"It is scarcely necessary to ob that the vast resources of England during the last fifty have depended on her improved machinery. It has ii been said with equal truth, that her independence nation rests upon her being twenty years in advance o neighbours. And never was it more necessary to mai such pre-eminence than at this time of great stri when the importation of wheat and flour has been mad to all nations, before the agricultural and milling inte and the large capital invested in them, have been pre to meet the competition of the world. Thus it is improvements in these important departments of B industry are now more especially occupying the se attention of some of the first minds in the kingdom— the prince to the peasant—as a necessary requiremen their profitable continuance."

The author hopes that the circulation of this little vo may stimulate inquiry and research among the practica operative men into whose hands it may fall; and tha facts and circumstances which have rather been indi than described, may form as it were the text, which in able and experienced hands may be amplified and illust The work has been hastily written at intervals, whe author could spare a short time to add a few pages note down a few observations as they might occur, wi much opportunity of arranging them afterwards.

This will be apparent to all who may read this and it will also be noticed, that the words of the au quoted throughout the volume, are generally give they were found, in the phrase of their own style time, so that the lesson may be learned as they t it. It has been exceedingly gratifying to the au and he has much pleasure in acknowledging it, whenever he has had occasion to verify a fact, to c *a statement*, or to ask information, he has, in

APPENDIX.

CENTRIFUGAL AND ROTARY PUMPS.

In the preceding pages the reader will have observed that several machines derive their power from the reaction of water-pressure: such as Dr. Barker's mill, Whitelaw's mill, the Vortex-wheel, and others. If these machines be impelled by some other power, and caused to revolve by an equal external force, say that of a steam-engine, they may be made to act as pumps; and as they had before been put in motion by the pressure of a column of water descending and passing through them, they would, by inverse action, raise a corresponding column of water to the like height.

Let the most simple of these machines, Dr. Barker's mill (fig. 15), be turned upside-down,—let the funnel mouth at the top, there shown as receiving the water, be immersed in a well, and the machine caused to revolve rapidly on its axis; the swift rotary motion will cause a partial vacuum in the arms, and the water will rise in the central pipe and fill them until it is thrown out at the holes near the ends, where the centrifugal force will cause continuous streams to be discharged so long as the requisite velocity is maintained.

The straight form of the arms, however, causes a considerable loss of effect: the course the water should take is that of the curve compounded of its radial direction, and of the rotary motion of the machine, for any radial velocity in the water, at the point of discharge, is power uselessly expended. Another centrifugal machine, having the same diameter, section, and apertures, but having the arms bent to the proper curvature, will discharge more than double the quantity of water in the same time with the same power—(see figs. 18 and 20). This was proved by direct experiments made by Mr. Hensman, at the request of the jury, during the Great Exhibition.

Thus Mr. Whitelaw's mill will be found to make a very effective machine for raising water, by reversing its action; and hence it *was that the* jury found Mr. Appold's wheel, formed with vanes *similarly curved*, produced so much greater results than wheels of *the same* dimensions with straight vanes. Mr. Appold's wheel *was only 12* inches in diameter; it received the water on each

gh apertures of 6 inches diameter, and had a central aphragm perpendicular to the axis, intersecting the ıing, as it were, a double wheel revolving between two t projected from opposite sides of the reservoir.

tex-wheel (fig. 25), perhaps, may serve to explain the ıperation of Mr. Appold's pump, by supposing the axis ontal, and the water to enter at the sides and be dis- ırough the large round pipe. When this wheel was st two others of the same size, the one with straight nes, inclined at an angle of 45 degrees, and the other l arms, the following results were obtained :—

	Revolutions per minute.	Gallons raised per minute.	Height raised.	Useful effect.
ld's wheel .	792	1164	18 ft. 8 in.	·649
„ .	788	1236	19 „ 4	·680
vanes . .	694	560	18 „ 0	·394
„ . .	690	736	18 „ 0	·434
nes . . .	624	369	18 „ 0	·232
„ . . .	720	474	18 „ 0	·243

eriments were made under the direction of Colonel d the amount of motive power employed was as- ɔy the dynamometer, constructed by M. Morin, on a roposed by General Poncelet.

hor was present during some of these trials, and was ı witness the care and skill with which they were con-

tting the water at both sides, the atmospheric pressure ɜed and balanced ; this is not the case in Whitelaw's nt, although a similar method has been used in other ıs in the "Fan-Blast," for blowing furnaces and forges, rhich of large size have been constructed by the author, ıes, similar to the rotary-fan, have also been applied to .

a long practice in the drainage of extensive tracts of Marsh lands, by steam-power, where natural drainage cticable, the author employed *Scoop-Wheels* to throw er. These were like the Breast-wheel reversed, and the y imagine their action by referring to fig. 29, and the wheel to lift the water, instead of being turned by heels like this, 28 feet in diameter, driven by steam- ɜre constructed by the author, at the Butterley Iron- e years ago, for the drainage of Deeping Fen, near ontaining about 25,000 acres, then often covered with *now growing* corn. One of these is found sufficient, *ery rainy* seasons, to keep the Fen clear of water. It *y an* engine of 80 horse-power, and the floats, or

ladle-boards, travel at a mean rate of 6 feet in a second: these measure 5¼ × 5 feet, and deliver a constant stream of water, with a sectional area of 27½ square feet, which moving at the speed abovenamed, discharges 165 cubic feet, equal to more than 4½ tons of water in one second; or about 16,200 tons in an hour. A more simple or effectual mode of raising a large body of water to a height of ten or twelve feet (from surface to surface) cannot well be devised, nor one less liable to derangement, from ice, weeds, and drift-wood. By this means upwards of 125,000 acres of Fen-land in England have been cleared of water under the author's direction, besides similar works of drainage in Holland, Germany, and in British Guiana, where the same machinery also irrigates the land in the dry season. For the drainage of small districts, it is probable that rotary or centrifugal pumps may be used with advantage. The number and variety of these machines, exhibited at the Crystal Palace, in 1851, and the elaborate and valuable experiments then made, have afforded data for their construction and improvement, which will tend to make their application to such purposes more general, and prove one of the many benefits resulting from that ever-memorable display of industry and ingenuity.

THE END.

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